

Application

- Advanced algebraic techniques
- Apply to solid modeling



May 20, 2002

NSF/DARPA CARGO
Kickoff Meeting

Robustness Problems

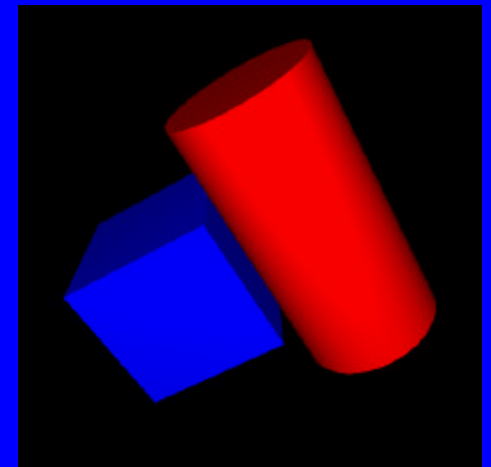
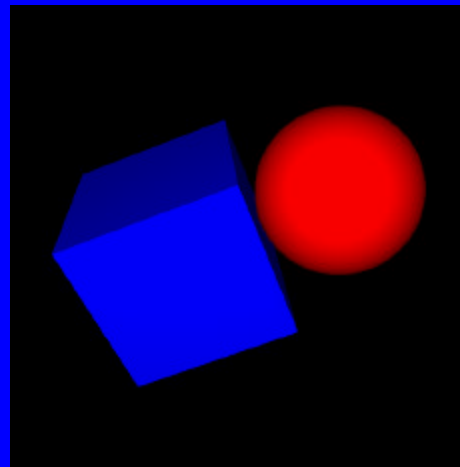
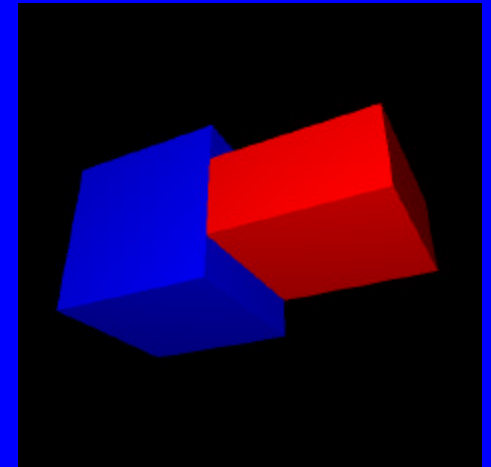
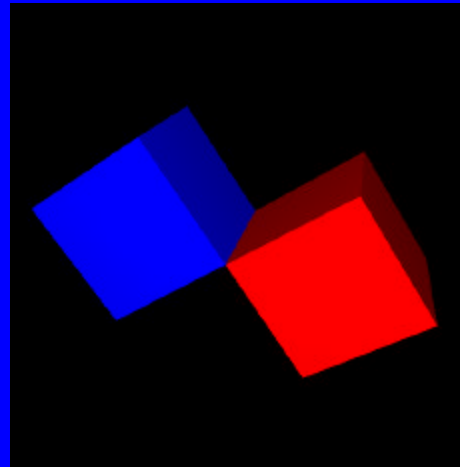
- Operations fail
 - Program crashes
 - Incorrect output
- Two primary sources:
 - Numerical error
 - Accumulated (roundoff)
 - Input
 - Degenerate situations

Degeneracies

- Objects violate assumption of general position
- Occur regularly in real-world situations
- Usually treated as special cases
 - Symbolic perturbation methods also used

Degenerate Configurations

- Two solids
- Problems may be algorithm or representation dependant



Curved Surfaces vs. Planar Surfaces

- More types of degeneracies
 - e.g. surfaces tangent at a point
- Degenerate situations more complicated
 - e.g. overlapping surfaces
- Computations more involved

Degeneracies and Numerical Error

- Numerical error can create degeneracies
- Numerical error can eliminate degeneracies
- Thus, high precision is needed to treat degeneracies thoroughly

Motivation

- Problem domain: solid modeling
- Degeneracies are common
- Robustness is important
- Powerful techniques available

Our Goal

- To *efficiently* detect degenerate configurations of solids
- Make use of toric resultant when possible
- Use both exact and smart approximate computation

Domain

- Specific problem: boundary evaluation
 - Assume rational parametric patches w/rational coefficients at first
- Methods should apply to similar CAGD problems
 - Surface intersections
 - Curve and surface arrangements

Prior Work - ESOLID

- Exact boundary evaluation in “reasonable” time
 - 1-2 orders of magnitude slower than inexact on real-world examples
- Does not handle degeneracies
- Uses exact computation everywhere

Classification of Degeneracies

- Enumerate types, group into similar categories
- Example: 4+ surfaces meeting at a point:
 - Vertex on face
 - Intersecting edges
 - Vertex on edge
 - Coincident vertices

Quick Rejection Techniques

- Quickly determine that certain categories do not exist
- Examples:
 - Bounding boxes
 - Interval computations
 - Modular arithmetic

Precomputation

- For specific problems, resultants have similar structure
- May precompute certain parts symbolically
- Make resultant computation faster for specific problem

Implementation and Application

- Incorporate into current exact boundary evaluation program – ESOLID
- Apply to real-world example
 - ESOLID handles BRL-CAD models
 - BRL-CAD creates CSG models
 - Convert to B-rep

Bradley Fighting Vehicle

- Low-degree solids
- 2725 objects
- 0-20+ CSG operations
- Many degeneracies
- Model and BRL-CAD provided courtesy of Army Research Lab



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Using Resultants

- Already a key part of curve-curve intersection routines
- Use to detect/reject several categories of degeneracies
- Apply to both exact computations and smart approximate computations

Using Resultants (continued)

- Reformulate current solution methods
 - Take advantage of faster resultant computation
 - Apply approximate computation as appropriate
- Goal: more efficient and usable robust implementation geared to specific problem

Project Organization

- 2 PIs
- 2 Graduate Students
- Research: Toward efficient degeneracy detection, using toric resultants
- Education: developing joint Math/CS course

Questions?

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